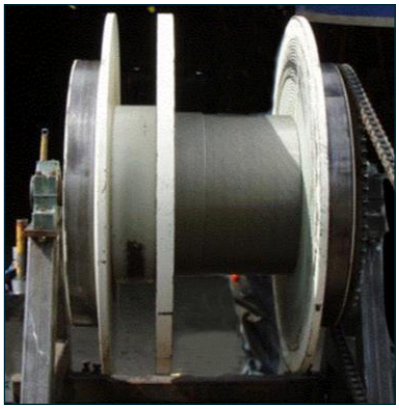
New Cables
Understanding Issues and Tips for Longevity



Although counter intuitive, wireline cables are most susceptible to damage during their first few runs in and out of the wellbore. Exposure to the wellbore environment "seasons" a new cable, preparing it for future work. These first few runs are critical to ensure maximum trouble-free cable operation.

A new cable undergoes important changes in tension, temperature and rotation when it is first put into service. During field operations, cable tensions and wellbore temperature are much higher than during manufacturing. These repeated higher tensions at elevated temperatures produce an embedment of the inner armor into the conductor insulation and a reduction in the new cable diameter by approximately 0.005 inches. Quality wireline cables are fabricated using a series of pressure rollers to partially embed the inner armor into the plastic core before the outer armor is applied. This process reduces the diameter changes typical of a new cable, which starts the seasoning process in advance of running in a well. See the picture to the right. The insulation, depicted in red, shows the indentation made during the manufacturing of Quality Cables.

All wireline cables feature an armor design that develops a torque proportional to the load on the cable. The torque of the outer armor wires is always greater than the opposing torque of the inner armor wires because there are typically more armor wires on the outer, and the distance from the center is larger (increasing leverage). Under load, the dominating outer armor will attempt to rotate and unwind the cable until there is a torque balance between the armor layers.

During manufacturing, a cable is subjected to only a few hundred pounds of tension, thus there is essentially no torque in a new cable as delivered. When installed on a truck, the spooling tensions are significantly higher than during manufacturing. Since the cable is not free to rotate, it will develop significant torque. During the first field operations, this new cable will attempt to rotate to normalize this built-up torque, as well as to support the tool string weight. To illustrate the significance of this problem, consider a new 5/16-inch cable deployed in a straight 20,000-foot well. The total rotations that a new cable end would require to equalize the torque could be over 400 rotations.

Forum's QWC team has addressed the problems associated with cable rotation by including a special blocking material that increases the friction between the inner and outer armor, reducing cable rotation. After repeated operations, this initial blocking material is slowly lost. In standard cables, which use galvanized steel armor wires, the spaces left by the loss of blocking material now become filled with the corrosion byproducts of zinc and iron. These byproducts, combined with the roughening of the wire from corrosion, increase the friction between the inner and outer armor, reducing cable rotation.

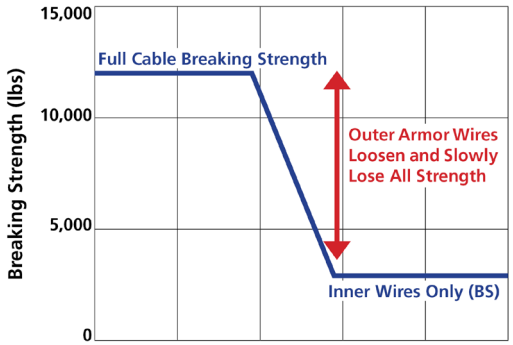
Cables using special alloy armor wires have been developed for operations in hydrogen sulfide (H2S) and highly corrosive well conditions. Alloy wires do not pit or generate corrosion byproducts. In the absence of friction typically caused by corrosion, alloy cables rotate freely throughout their life after the initial blocking material is lost.

Operations using alloy cables occur frequently in wells containing toxic gases where hydraulic packoffs are generally kept much tighter than in regular operations. These conditions result in additional cable unwinding and loosening of

the outer armor. Throughout their lifetime, alloy cables must have the armor tightened and set with post-forming. No standard rules exist for servicing alloy cables, but it is a good practice to bring a new alloy cable to a service center after the first job and thereafter every 10 to 20 runs.

All cables that become loose — particularly new cables — are more susceptible to damage, including drum crush, outer armor wires being "milked" into a "birdcage" and reduced breaking strength. Importantly, the breaking strength of a normalized cable comes from all the inner and outer armor wires combined. When a cable becomes loose, the load is shifted from all wires to only the inner wires, which dramatically reduces the breaking strength as shown on the graph.

Breaking Strength Loss As Outer Armor Wires Loosen on a 5/16" Mono-Conductor



Tips to Prevent Damage to New Cables and Increase Cable Life

At Forum, we understand that the following suggestions occur under ideal conditions, and in many operations, these suggestions may not be practical. However, it is important to understand that if employed, these practices will increase cable life.

- To allow a new cable to rotate and become "normalized," it is important to choose the first operations carefully. Select operations with minimum mechanical drag downhole. There should be little or no packoff pressure required, and the hole should be fairly straight. In practice, boreholes are never straight, and the end of the cable is never completely free to rotate. It takes a new cable several trips in the hole to spin out and become normalized. Follow the same rules any time a new part of the cable comes off the drum for the first few times.
- Coming out of the hole, cable tension is increased due to friction and weight of the tool string. This higher tension will cause the cable to rotate and the outer armor to unwind. Line speed is a critical parameter. The faster the cable is run in the hole, the less tension it experiences. Coming out of the hole at high speeds creates increased tension and captures the cable in a loose condition. When going back in the hole, tension is reduced, and the cable will rotate to tighten the outer armor. To allow a cable to wind and unwind normally, good operating rules are:
- While going in the hole, do not allow the tension at any depth to fall below two-thirds of the static tension at that depth.
- Come out of the hole at a speed not greater than the speed that increases the tension by more than one and one-third of the static tension at that depth.
- When special operating conditions do not allow for normal cable speeds or when tight packoffs are needed, the cable will unwind and develop loose outer armor. To correct this condition, the cable should be taken to a cable service shop to have the armor tightened and post-formed. Otherwise, the cable's ultimate breaking strength could be jeopardized.
- When running in the hole with new cables, stop every 1,000 to 2,000 feet (or whenever the customer permits) to allow the cable to regain tension and properly spin out. At this point, pull back 50 to 100 feet before running further into the well.
- Avoid deviated wells if possible until the cable is seasoned.
- Avoid any pressure with a hydraulic packoff and ensure the flow tubes have a minimum 0.004- to 0.006-inch clearance.